DOCUMENT RESUME

ED 187 755 TM 800 261

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TITLE Brain Growth Periodization in Young Adolescents: Some Educational Implications.
PUB DATE Apr 80
NOTE 18p.; Paper presented at the Annual Meeting of the American Educational Research Association (64th, Boston, MA, April 7-11, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Academic Achievement; *Adolescent Development; Adolescents; Children; *Cognitive Development; Cognitive Measurement; *Developmental Stages; *Elementary Secondary Education; *Learning Readiness; *Neurology
IDENTIFIERS *Brain Growth Periodization

ABSTRACT

Research findings in the area of brain growth periodization establish that the human brain does not grow on a constant continuum. Eighty-five to ninety percent of youngsters of average and above ability experience periods of great brain growth between ages 3-10 months, 2-4 years, 6-8 years, 10-12 years, and 14-16+ years. Mental growth data have indicated that between ages 10-12 years, an average growth of almost 40 months in mental age is experienced, while such an average drops to 7 months from ages 12-14 years. During the same intervals, it has been found that there is virtually no growth in the brain mass. This points to the need for a reexamination of middle grades educational practice in terms of expectations and strategies, because when teaching strategies are based upon cognitive levels and capacities of learners, information is learned more efficiently. (GSK)

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BRAIN GROWTH PERIODIZATION IN YOUNG ADOLESCENTS: SOME EDUCATIONAL IMPLICATIONS*

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*PREPARED FOR PRESENTATION TO SESSION E-7, RELATIONSHIP BETWEEN DEVELOPMENTAL RESEARCH AND CURRICULUM AND INSTRUCTION IN MIDDLE SCHOOLS, SYMPOSIUM E-7, AT THE ANNUAL MEETING OF THE AMERICAN EDUCATIONAL RESEARCH ASSOCIATION, BOSTON, MASSACHUSETTS

APRIL 10, 1980

8:15 - 10:15 A.M.

TM 800261

BRAIN GROWTH PERIODIZATION RESEARCH FINDINGS:

IMPLICATIONS FOR EDUCATING CHILDREN

The organization of teaching-learning situations in the American school system reflects a kind of faith in an assumed, constant continuum of mind and thinking capacities of learners during their formal education years. The organization of subject matter for such learning reveals a concern for gross, quantitative growth of learners across their years in the educational system. This existing practice reveals no great concern for changing mental capacities of learners with regard to differences of kind of modality of learning possible at specific ages. While teachers may respond to such changes in learners' thinking capacities within their own classes, expectation for quantitative growth in mastery of information and skill development across the total elementary-secondary program, gives little indication of such awareness on the part of curriculum builders.

While Piagetian findings have had increasing impact in the minds of educational and learning psychological theorists, the program of instruction in the nation's school systems has experienced remarkably little change in view of such findings. This writer contends that the area of brain growth periodization findings may have far more reaching impact on the organization of elementary and secondary curriculum. Indeed, the interface of these with Piagetian findings, may combine to create the development of a public school curriculum far more responsive to the intellectual differences and realities children experience as they progress in their journey from early childhood to complete adolescence.

Brain growth periodization findings refute the idea of a constant continuum of growth of mind and thinking capacities in the development of children. The supporting data for the concept of brain growth periodization come from the interface of research data from the areas of anatomy, biophysics and developmental neurobiology and confirm that the brain, like other organs, does grow in stage-wise fashion. Epstein (1974) identifies that stage-wise growth confirms that organs experience highly chronologically predictable growth spurt stages. The incidence of a growth spurt means that the organ is developing the capacity for higher level functioning and the initiation of higher level capacities during that growth spurt. The Epstein findings also confirm periods of alternating growth spurt stages interfaced with growth plateau stages create the pattern of periodization of growth in the brain. Epstein (1977, 1978) has specified the reality of growth periodization of the brain through correlation with data from a range of existing researches.

Eighty-five to ninety percent of youngsters of average and above ability experience periods of great brain growth between ages 3-10 months, 2-4 years, 6-8 years, 10-12 years, and 14-16+ years. Epstein (1979) observes that the first four of these brain growth stages are on the onsets of the classic Piagetian stages. The latter is also on the onset of the identified fifth Piagetian stage researched by Arlin (1975). This is not to assume that, for instance, on the dawn of the tenth birthday, a youngster enters a twenty-four month period of unbridled brain growth which comes to a screeching halt on the twelfth birthday. The reality is that eighty-five

to ninety percent of these youngsters will experience their personal brain growth spurt period during the age 10-12 years interval.

The Epstein data similarly identify that the same percentage of students experience intervening periods of plateau of brain growth during ages 4-6 years, 8-10 years and 12-14 years with again, the personal plateau occuring sometime within each of those interval periods. For focus in this paper, the age 10-12 years growth spurt and the age 12-14 years plateau period are of greatest concern.

Before examining the implications of the alternating growth spurt and plateau of growth periods occuring between age 10-14 years for middle grades, some consideration of the nature of both growth spurt and plateau periods is in order. The immediate question which comes to mind is the relationship of growth of brain to the function of mind and learning. Epstein (1979) states that cell replication in the brain, as measured by DNA synthesis, terminates by about 18 months, meaning that the last four brain growth stages occur without any increase in the number of brain cells. Epstein contends that this size increase in the brain is accounted for by very substantial increase in protein per brain. For neurons, this increase in protein is manifested in the elongation and branching of axons and dendtites. Thus, there is a substantial increase in the complexity of the neural networks in each of the last four brain growth stages (ages 2-4, 6-8, 10-12 and 14-16+ years). This could correspondingly express itself functionally in a substantial increase in the complexity of the thinking process of the brain.

Huttenlocher (1979) has established that children at age 2 have higher density of synapses per cubic millimeter of cortical brain tissue than adults. While scientists had previously thought that density of synapses increased with age, his data confirm that the synapses shift during periods of brain growth. The increase of cognitive ability during the brain growth stages also infers the possibility of the maturation of synapses during the brain growth intervals. Huttenlocher's data was gathered through a special electron microscopy method to perform post-mortem analysis of frontal cortex cells. His findings also confirm that of dendritic growth continues even though the number of synapses per neuron declines. Thus dendrites continue to expand during the brain growth spurt periods.

Epstein (1979) has found that there is virtually no growth in the brain mass and no significant increase in the complexity of the neural networks during the brain growth plateau periods at ages 4-6, 8-10 and 12-14 years for eighty-five to ninety percent of youngsters. This reversal of the patterns found in the growth spurt periods (age 2-4, 6-8, 10-12 and 14-16+ years) should cause a serious re-thinking of our educational expectations for how and what children can learn during the intervening brain growth and growth plateau periods.

General implications for learning differentiate between those for youngsters during growth spurt intervals and those in growth plateau intervals. Epstein (1977) and Epstein and Toepfer (1978) see that initiation of new and higher level cognitive processes should be successfully undertaken with high probability for success during periods of brain

growth. The extension of neural network accompanying this time predicts this possibility. On the other hand, it appears that learning which stresses the continued introduction of new and higher level cognitive processes will be far less successful during the brain growth plateau intervals. The lack of the addition of neural network during these intervals also reinforces this prediction.

The history of middle grades education recognizes the problems of learning found during the age 12-14 years interval. The personal, social and emotional realities of the pubescent metamorphosis (Toepfer, 1973) provide traumatic distractions to academic focus, especially when one considers the wide range of the time of adolescent arrival among emerging adolescents. The lack of clarification and separation of fact and folklore in the mystique of pubescence has hindered past efforts to draw focus on realistic expectations for intellectual and cognitive progress during these years. While the data have existed for decades, Epstein (1977) correlated these data in physical and mental growth with the age 10-12 and 12-14 years intervals. Mental growth data, beginning with Shuttleworth (1939) have indicated that between age 10-12 years, youngsters experience an average growth of almost forty months in mental age while such average growth drops to seven months during the age 12-14 years interval. These findings correlate with the Eichhorn and Bayley (1962) and their study of periods of growth of head circumference in children. The interface in these findings among brain growth periodization, mental age growth and head circumference points clearly for the need to re-examine existing

middle grades practice in terms of expectations and strategies for the age 10-14 year population. A separate focus and emphasis in each of the age 10-12 year and 12-14 year components of the middle grades period appears essential. This writer (1979) bases his concern from observation and work in the middle grades throughout his career. Youngsters who can learn new facts, skills and information during age 10-12 years often seem to lose this capacity during their age 12-14 year period. Despite effort and concern, achievement drops severely. It seems important to consider an observation by Epstein that one should never give a learner an input for which the necessary receptor has not been developed. In that sense, we know that during the age 10-12 years interval, eighty-five to ninety percent of youngsters will experience a brain growth spurt with substantial increase in neural network. During this time we observe that youngsters can both learn new facts and increasingly higher thinking skills and cognitive processes. An anology from baseball suggests that during such times, teachers can "pitch" the new facts and information in an expansive "strike zone." The youngster's increasing neural capacity means that new facts can be learned through reasonably increased thinking and cognitive skills. Thus the learning of new facts and information can be successfully attached to the learning of increasingly higher or new cognitive processes during the brain growth spurt experienced during the age 10-12 years interval. The extension of the same anology into learning strategies during the ensuing age 12-14 years growth plateau period means that teachers must now "pitch" new facts and information within a fixed "strike zone." With

the lack of increasing neural capacity during the brain growth plateau experienced at a time during the age 12-14 years interval, new facts and information can be learned most effectively when "pitched" within the existing profile of skills initiated or developed by the youngster during his completed brain growth period. The learning of new facts and information as well as the refinement, consolidation and maturation of thinking skills and cognitive processes initiated during the brain growth period will be facilitated. The problems of academic achievement found in the age 12-14 years interval as opposed to a lower incidence of these conditions in the age 10-12 years period lead to a frightening observation. Perhaps such "over-challenge" in terms of moving to higher cognitive processes and thinking skills in teaching strategies during the age 12-14 years interval builds in a "no-win" situation for large numbers of students. In such "over-challenge", not only is the movement to new and higher level thinking skills and cognitive processes unfeasible for a majority of youngsters; their learning of new facts and information becomes cumberson and difficult, if not impossible. In like measure, challenge at a realistic level is not present and opportunity to refine, consolidate and mature existing thinking skills and cognitive processes is seriously handicapped.

The examination of these conditions in the middle grades makes it imperative to identify the development of children in terms of their thinking capacities during the alternating growth and plateau stages. The research of Shayer and his associates (1976, 1978) has identified that the percentages of children showing mature concrete operations or higher

levels increase only at the ages of the brain growth stages. This reveals a strong correlation of thinking level change to the appearance of new complexity in the neural networks manifested during the brain growth stages. Epstein (1979) reports the distribution of percentages of youngsters at thinking stages as it has impact for youngsters in the American educational setting. (See Figure I.)

The occurence of the brain growth plateau period at a time within the age 12-14 years interval should cause us to predict little increase in intellectual abilities in that period. As Epstein (1979) observes, data from Figure I reveal that, indeed, only a small minority of children could have shown any change in level during that period. The capacity to develop formal operations during this time is revealed as achievable for such a small number of youngsters in Figure I, that even at age 14 years, seventy-six percent of learners are still unable to handle material presented at the level of formal reasoning. As Shayer (1976, 1978) has shown, even the top twenty percent of youngsters at age 14 years will show thirty percent of that group who do not display formal operations. Epstein (1979) again observes that this is not surprising since IQ is related mainly to speed of learning while cognitive level is related to style of learning.

It well may be that the brightest of our middle school youngsters are not learning at formal reasoning levels as much as they are exercising gross memorization of massive bodies of data and procedures. The organization of considerable middle grades learning tasks unfortunately lend themselves too much to memory-recall than explicit demonstration of problem-solving by learners.

Research in school settings is needed to provide data which tests the implications for middle grades education suggested here. Where teachers have been prepared to respond in terms of the cognitive levels actually achieved by learners during the age 12-14 years period, learning of facts and information surpassed the control settings in which the typical middle grades teaching strategies were utilized. It appears that when middle grades teaching strategies are based upon cognitive levels and capacities of learner, information is learned more effectively and that learners have opportunity to consolidate, refine and mature their thinking skills initiated during their previous brain growth stages. There is also some suggestion that when given alternatives of cognitive level placement in discussion with teachers, learners will self-select their actual cognitive level with a high degree of accuracy. These assumptions require validation through experimental-control investigation in school settings.

Further concerns about differences among average and high ability students must consider the findings of Webb (1974). How work with large numbers of gifted youngsters between age 6-11 years indicates that the incidence of formal reasoning is so limited, even in this select population, that the data on youngsters shown in Figure I holds true for high ability students as well.

Examination of middle grades practices reveals an emphasis upon formal operations level teaching to a far greater degree than that shown by data from Figure I. Programs in grades seven and eight, during which time most youngsters experience their age 12-14 years time-frame, appear to seriously

overshoot the cognitive capacities of large percentages of learners. Assessment of teacher expectation and cognitive level of materials and strategies utilized between age 12-14 years is critical in defining realistic expectations for intellectual growth as the result of learnings offered in school during that interval.

A final implication for the middle grades lies in the incidence of sexual dimporphism found between boys and girls at age 11-12 years and at age 14-15 years. Epstein (1978) points out that between age 11-12 years, the second half of the age 10-12 years brain growth interval, girls experience a two-to-three fold advantage in brain growth over boys. The reversal of this phenomenon occurs in favor of boys between age 14-15 years. It could be hypothesized that girls need a different kind of curriculum at that age. The success of boys over girls in study of analytical and theoretical areas beginning at age 14 continues through higher education. The resultant success of males over females in the more theoretical or abstract professions is an enigma in terms of the advantage in intelligence females possess over males.

Neurology maintains that if newly developed capacities are not challenged, they tend to atrophy. Since school curricula introduces the serious study of analytical and theoretical areas between age 14-15 years, the following questions arise. To what degree is the success of boys over girls in these areas due to the fact that instruction takes on a serious focus at virtually the same time when boys experience a two-to-three fold advantage in brain growth over girls? Also, to what degree is there causality in that girls

do not begin such study until almost three years after they experienced a similar advantage in brain growth over boys? Does the possibility of atrophy of this capacity in girls have any relation in the eventual success of males over females in study in these areas or entry into analytical or abstract professions? Certainly a number of working hypotheses can be developed here which lend themselves to experimental study in curriculum development and learning strategies within the middle grades setting.

It is important that middle grades educators recognize the scientific fact of brain growth periodization. The myth of constant development of thinking capacity in the emerging adolescent mind can now be put to rest. It is important also that the areas discussed here continue to be tested to gain data for developing more responsive curricula for middle grades programs. The success of cognitive learning, development of cognitive processes, and the improvement in the effectiveness of the middle grades learnings for the total development of emerging adolescents will, in a great measure, depend upon the serious researching of the implications suggested here. While the refining of tests to identify cognitive levels of students continues, the work of Sund (1976), and Ankney and Joyce (1974), Burney (1974) have been of great help in experimental work to-date by Epstein. The tests developed by Shayer (1976, 1978) and continuing separate efforts of Shayer, Arlin, and Anton Lawson promise to provide educators with more advanced testing instrumentation which will lend itself to more effective utilization in continuing research and by classroom teachers in regular middle grades settings.

The implications of this beginning work undertaken to investigate the realities established by brain growth periodization provide a fertile area for continuing research. This writer views the continued investigation of this area an imperative of the highest priority in seeking ways to improve the middle grades area.

AGE (YEARS)	PRE OPERATIONAL	CONCRETE ONSET	CONCRETE MATURE	FORMAL ONSET	FORMAL MATURE
5	85	15			
6	60	35	5		
7	35	55	10		
8	25	55	20		
9	15	55	30		
10	12	52	35	1	
11	6	49	40	5	
12	5	32	51	12	
13	2	34	44	14	6
14	1	32	43	15	9
15	1	14	53	19	13
16	1	15	54	17	13
17	3	19	47	19	12
18	1	15	50	15	19

FIGURE I

(Taken from Epstein, 1977)

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